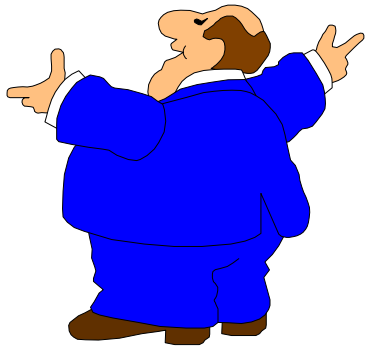
# PH Craftsman Course
# CFSP Review

## Foodborne Pathogens



# Overview

- The problem
- Types of foodborne illness
- Microorganisms in foods

  Are they all bad?
- Food pathogens
- Transmission of food pathogens

# The Food Pathogen Problem

- Estimates of foodborne disease in U.S./yr:
  - 6.5 to 33 MILLION foodborne illnesses
  - Up to 9,000 deaths
  - Hospitalization costs -- > $3 billion
  - Lost productivity -- > $9 billion
  - Under-reported!

*Adapted from:* Council for Agricultural Science and Technology. Foodborne Pathogens: Risks and Consequences, 1994.

# Foodborne Illness (2 types)

1. **INFECTION**
   - Ingestion of MICROBES IN FOOD causes illness. The microbes cause disease by:
     - Invasion of the gut/body

     **or**

     - Toxin production *in the GI tract* (termed a "toxin-mediated INFECTION"

## 2. INTOXICATION

- Ingestion of FOOD CONTAINING TOXIN causes illness
- Microbes produce toxin while growing in food
  - Ingestion of the microbes themselves may be harmless
- Also: Chemical contamination of food such as pesticides

# Microorganisms in Food

- Bacteria
- Viruses
- Parasites
- Fungi

# Microorganisms in Food: **Bacteria**

- Pathogens
- Spoilage bacteria
- Bacteria used in fermentation to enhance the flavor of foods/beverages

Let's focus on bacterial pathogens. *We'll start with bacteria causing foodborne intoxications…*

# Bacteria Causing *Intoxications*

- ***Staphylococcus aureus*** ("Staph")
  - Reservoir: Common on human skin and in nasal cavity--therefore commonly a problem in foods that are handled a lot
  - Transmission: Must multiply in food to produce enough toxin to cause illness
  - Disease: Primarily causes vomiting
  - Incubation period: Short; usually 2 - 4 hours
  - The bacteria is killed by cooking, however the toxin is *not* destroyed by normal cooking!

- ***Clostridium botulinum*** ("botulism")
  - Reservoir: Spores found in soil and water (ocean/lakes)
  - Transmission: Associated with improperly canned foods and ground-harvested foods such as onions and garlic
  - Disease: Toxin causes paralysis
  - Incubation period: ½ day to 3 days
  - Spore is difficult to destroy, *but* botulinum toxin CAN be destroyed by cooking (e.g., 176F for 10 min)

- ***Bacillus cereus* (Emetic Form)**
  - Reservoir: Spores found in soil, grains
  - Transmission: Associated with improperly hot-held or improperly cooled foods (rice, cereals)
  - Disease: Emesis primarily
  - Incubation period: Short; 1 - 6 hours
  - Another heat stable toxin

# Review of bacterial intoxications

- What were the three bacterial organisms that cause foodborne intoxications?

# Bacteria Causing *Infections*

- ***Salmonella spp.* (non-typhoid)**
  - Most common cause of bacterial foodborne disease using *passive* surveillance
  - Reservoir: many food-producing animals
  - Transmission: Associated with undercooked meats (especially poultry) eggs, raw milk, and contaminated produce
  - Disease: Diarrhea and systemic infections
  - Incubation period: ½ day - 1½ days

- 1994 ice cream outbreak (>200,000 cases)
- Common pathogenic strains:
  - *S. enteriditis, S. typhimurium*
  - *S. typhimurium* DT104
    - Multidrug resistant

- **Typhoid**
  - ***Salmonella typhi*** or ***S. paratyphi***
  - Reservoir:  HUMANS
  - Disease:  fever, systemic
  - Incubation: days to several weeks

- ***Campylobacter spp.***
  - Most commonly isolated organism using *active* surveillance (CDC FoodNet)
  - Reservoir: Animals
  - Transmission: Associated with undercooked poultry and raw milk; also from direct contact with animals
  - Disease: Diarrhea (+/- bloody), systemic
    - Chronic sequela: Guillain-Barre syndrome
  - Incubation period: usually 2 - 5 days

- ***Escherichia coli* (*E. coli*)**

Types:

- Enterotoxigenic (ETEC)
- Enteropathogenic (EPEC)
- Enteroinvasive (EIEC)
- Enteroaggregative (EAggEC)

➥Enterohemorrhagic (EHEC)

- Animal reservoir
- *E. coli* O157:H7 & other verotoxin-producing *E. coli*

- ***E. coli* O157:H7**
  - Reservoir: Cattle, deer, other animals?
  - Transmission: Associated with ground beef, apple juice, fermented meats, raw milk, PRODUCE, WATER
    - Organism is unusually acid-tolerant
  - Disease: Diarrhea (usually hemorrhagic)
    - Sequela: Hemolytic Uremic Syndrome (HUS)
  - Incubation period: 2 - 9 days

- Low infectious dose
- 1 organism in ground beef is considered an adulterant!

- In over 24,000 USDA retail ground beef samples from 1994-1998, only 19 positives found
  - "Testing is like looking for a needle in a haystack the size of the Empire State Building" - *Mike Osterholm*

- ***Clostridium perfringens***
  - Reservoir: Spore found in animal and human intestines; soil
  - Transmission: associated with large cuts of meat (i.e., large roasts or turkeys), stews and gravies
  - Incubation period: 10 - 12 hrs (about ½ day)
  - Disease: primarily diarrhea

- ***Bacillus cereus* (Intestinal Form)**
  - Reservoir and Transmission: same as Emetic form
  - Disease: Diarrhea primarily
  - Incubation period: about ½ day to 1 day
  - Similar etiology/pathgenesis to *C. perfringens* -- a spore former that causes a toxin-mediated infection

- ***Listeria monocytogenes***
  - Reservoir:  the environment
  - Transmission:  Associated with many foods; often dairy and processed meats
    - Contamination of the food often occurs during processing/packaging
  - Disease:  Ranges from  mild, flu-like to abortions, meningoencephalitis, septicemia
  - Incubation period:  variable; days to weeks
  - Usually only serious disease in the very young, the elderly, or pregnant females

- ***Shigella spp.***
  - Reservoir: Humans
  - Transmission: Contaminated foods
  - Disease: Bacillary dysentery
  - Incubation period: usually 1 to 3 days
  - Also a common concern in child development centers
  - Low infectious dose

- ***Vibrio parahaemolyticus***
  - "Seafood Salmonella"
  - Associated with shellfish, other undercooked saltwater fish
- ***Vibrio vulnificus***
  - Reservoir: Saltwater
  - Transmission: Associated with consumption of raw shellfish
  - Disease: Death; 14 per year in US; immunocompromised at highest risk
  - Incubation period: 1 to 2 days

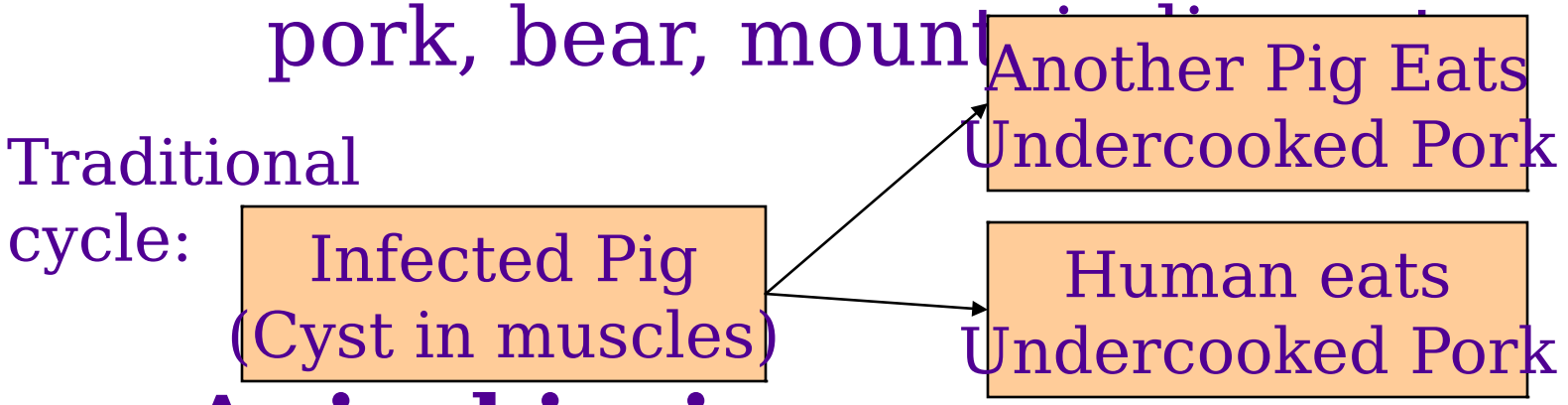
- ***Yersinia enterocolytica***
  - Associated with pork intestines
- **Cholera**
  - Associated with water/seafood

# Foodborne Pathogens: **Viruses**

- Human reservoirs (not zoonoses)
- Viruses can NOT multiply in food
- **Hepatitis A**
  - Causes jaundice
  - Long incubation period (15 - 50 days, avg = 30 days)
- **Norwalk virus, Norwalk-like viruses**
- **Rotavirus**
  - Infant diarrhea
- Others

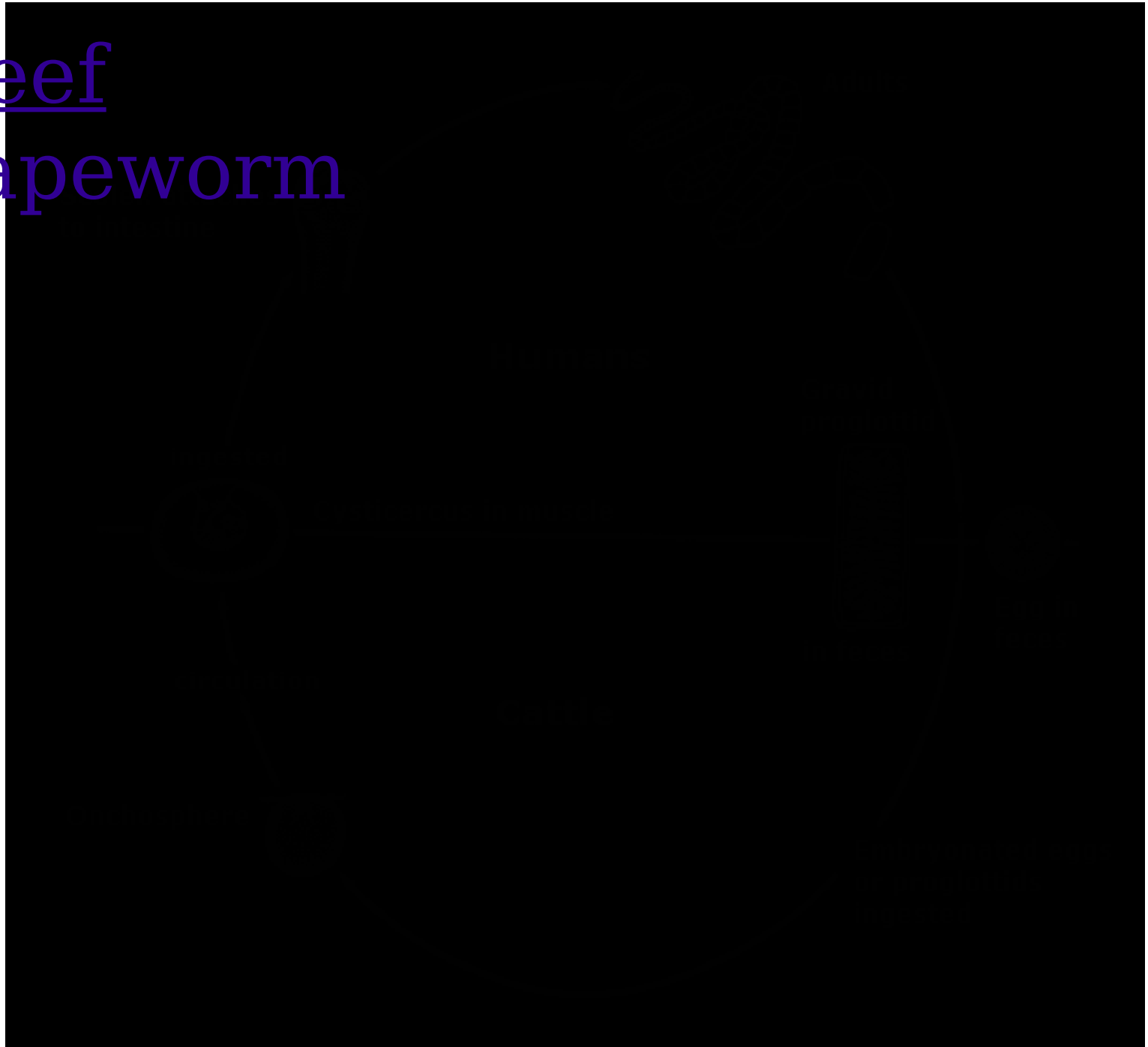
# Parasites: Worms in Foods

- **Trichinosis**
  - Associated with undercooked pork, bear, mount

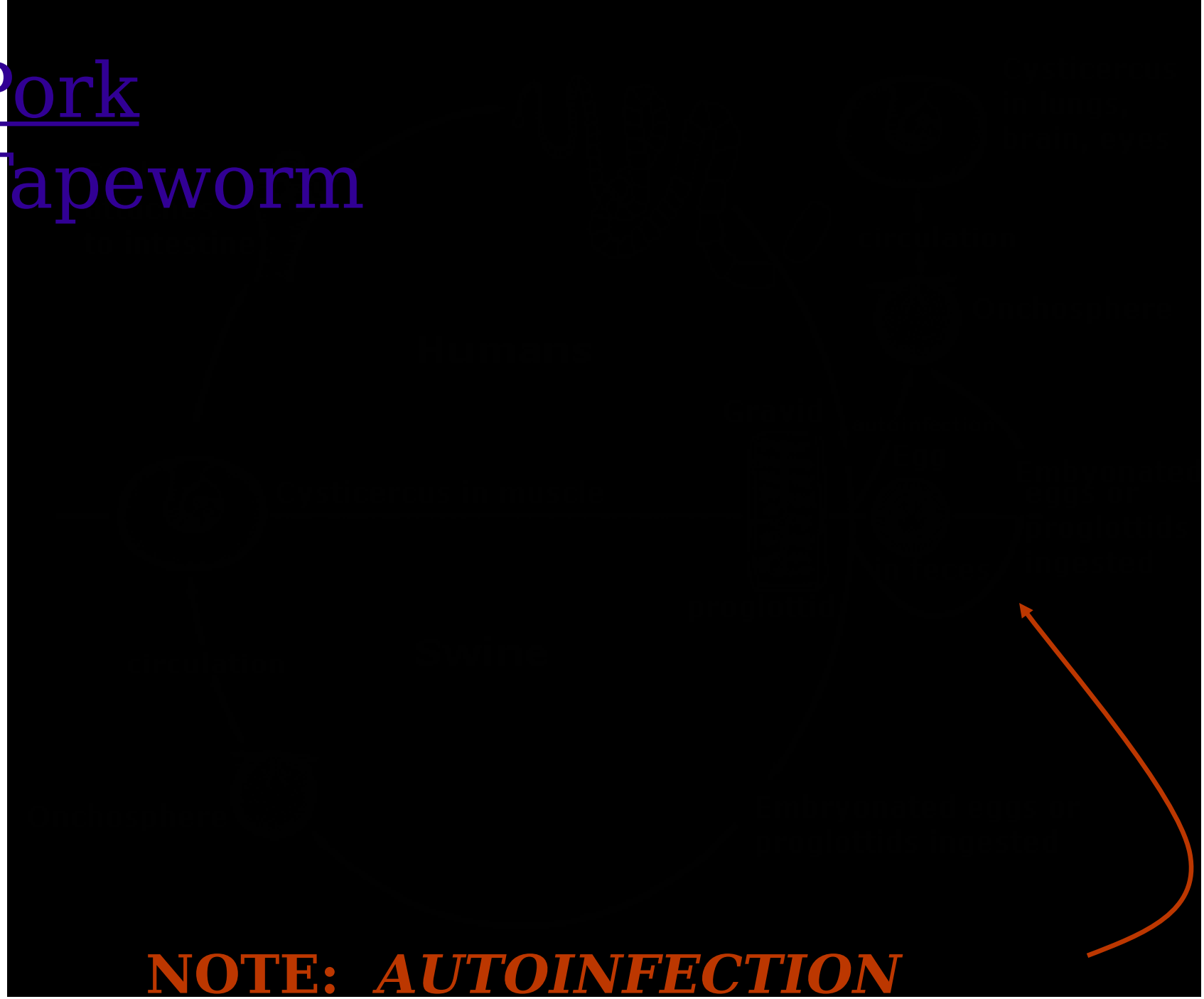



- **Anisakiasis**
  - Raw saltwater fish--watch out for sushi!
- **Tapeworms--**Beef and Pork

Beef
Tapeworm



# Pork Tapeworm



**NOTE: *AUTOINFECTION CONCERN!***

# Parasites: Protozoa in Foods

- ***Toxoplasma gondii***
  - Transmission: Undercooked meats, unwashed fruits & vegetables
    - Less commonly--cat feces
- ***Cryptosporidium parvum***
  - Mostly waterborne
    - 1993 outbreak in Milwaukee
  - Some foodborne--apple cider
  - Found in animal intestines

- ***Giardia***
  - Transmission:  associated with water
  - “Beaver Fever”
  - Other animals are reservoir
- ***Cyclospora***
  - Transmission: associated with water and FF&V
  - Multistate outbreaks in ‘96 and ‘97 -- Guatemala Raspberries

# Other Causes of Foodborne Illness: **Misc. Toxins**

- **Fungal toxins**
  - Mycotoxins (e.g., aflatoxin)
- **Seafood toxins**
  - **Paralytic Shellfish Poisoning (PSP)** in shellfish and **Ciguatera** in finfish
    - Both are pre-formed toxins from dinoflagellates in ocean (“Red Tide”)
    - The toxins are heat-stable
    - Other similar shellfish poisonings: DSP, DAP, NSP

- More seafood toxins:
  - **Scombroid**-tuna, mackerel, dolphin
    - Bacteria digest proteins in dead fish
      - Leads to histamine formation
      - Histamine is heat stable
      - Prevention--refrigeration & approved sources

# Review questions:

- Which types of organisms can grow (increase in number) in foods?
- What's the significance of toxins in foods?

# Transmission of Food Pathogens

Method depends on type of organism

- Contaminate food during handling or during processing (i.e., slaughter)
- Contaminate fruits/vegetables pre-harvest or during processing
- Poor sanitation
- Parasites in meats
- Contamination of water supply

# Transmission of Food Pathogens

- What's special about spore-formers?
  - What were the three of concern?
  - Spore survives cooking
  - When food cools for too long--spores enter vegetative state
    - Vegetative cells proliferate rapidly if food held at improper temperatures after cooking
    - These vegetative cells can cause infection or intoxication

# Transmission of Food Pathogens

- What’s the significance of organisms with a low infectious dose?

# Waterborne Pathogens

- Most of the same bacteria, viruses, and parasites that cause foodborne disease can also cause waterborne disease
- Pathogens that can be transmitted by the fecal-oral route have the potential to contaminate water and/or food
- Water is often used to prepare foods
  - Contaminated water can lead to contaminated food

# Summary

- Magnitude of the problem
- Types of foodborne illness
  - Foodborne infection *vs*. intoxication
- Microorganisms in foods
  - Bacteria, Viruses, Parasites, Fungi
- Food pathogens
- Transmission of food pathogens